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EFFECTS OF AND ON RECEIVING WATERS AND ENVIRONMENT (FLORA AND FAUNA) AND EFFECTS OF AND ON WATER TREATMENT PROCESSES AND PERSONNEL BY RADIOACTIVITY IN WATER SUPPLY

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by

Conrad P. Straub*

Mr. John Newell, Atomic Energy Commission, has given a very excellent review of the general methods of control and treatment as practiced at the various Atomic Energy installations. He has enumerated the sources of the wastes produced in the operation of such facilities and has described the techniques of treatment and disposal. He points out further that there is little information of a practical nature concerning the handling of high level wastes, except for storage, but that considerable study is being given to the over-all problem of handling, treating, and disposing of such wastes. This paper will discuss the effect of radioactive waste materials upon the environment.

EFFECT ON STREAMS

Radioactive liquid wastes pollute a stream in the same manner as any chemically similar waste. The radioactivity acts as an additional pollutant. As you all know, no chemical, physical, or biological process is effective in reducing radioactivity. Only time can effect such a change; the time needed is a function of the radioactive species under consideration and is characterized by the half-life of the species - the time required for one half of the activity initially present to disappear.

Sedimentation, coagulation, exchange of ions, adsorption, biological degradation, and biological assimilation, which affect the stabilization and decomposition of other waste materials, will account for the removal of some radioactivity. This removal does not represent a reduction in radioactivity, but merely the relocation of activity from one phase to another - in this case the transfer of material from a liquid to an associated solid phase.

A reduction in the concentration of the radioactive contaminants will take place as a result of subsequent dilution, dispersion, and

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self-purification, as the waste materials move downstream from their point of introduction. This again, however, is not a removal of radioactivity, since we have just as much material present in the stream in toto as we had initially. This statement holds essentially for the longer-lived materials. Where short-lived materials are discharged, decay of these materials will account for a substantial reduction of the initial activity present. In calculating the dilution available, great care must be observed in relating the activity to be released to the actual quantity of liquid passing the point of its introduction.[1] Unless adequate mixing takes place, the introduced materials will move through the sewers or in the streams as slugs. Furthermore, extrapolation of dilution data from single dose discharge to multipoint or even continuous discharge is exceedingly difficult and should not be undertaken without special study of the many natural factors operative in the removal of radioactive materials from the stream.

The effect of each of these processes upon the reduction of activity levels in the stream will now be considered in greater detail.

Sedimentation and Coagulation

The release of waste streams into water courses may result in chemical interaction between the two ingredients. Precipitates may form which will settle immediately or be transported downstream and deposited under reduced velocity gradients. Furthermore, turbidity normally encountered in many surface streams may remove some of the radioactivity and deposit it under suitable conditions of stream flow.

In stream systems similar to those in the Tennessee Valley area where many embayments exist, pockets of deposited activity may be formed as the normal stream elevations decrease. Subsequent high water will add new radioactive contamination, thus exposing fish and fish food sources to greater levels of activity. This is particularly important where long-lived radioisotopes may be discharged and collect in such areas.

Ion Exchange and Adsorption

Soluble radioactive materials released into streams may be adsorbed on particulate matter (turbidity, plankton, bottom muds, etc.) or ions may be exchanged onto the particulate matter. By either of these two mechanisms, liquid-phase activity levels will be reduced, and the activity will be found associated with the particulate matter.

Assimilation

Biological organisms, through normal metabolic processes, remove certain stable and radioactive constituents from the waste streams and concentrate these within their cell structure. The levels of activity accumulated in such biological forms may become very hig. For example, it has been reported that certain plankton forms concentrate phosphorus-32 to one and a half million times the level in the surrounding liquid. Such high levels of concentration have not been reported for the fission products, but levels exceeding the environmental level by several hundred to a thousand or more have been indicated.

Degradation

When biological matter is destroyed or dies, some of the accumulated radioactive materials previously adsorbed or metabolized may be returned to the water. Such release in activity may pose rather significant problems, particularly when associated with plankton blooms which may be destroyed.

Dilution and Dispersion

The writer does not like to consider indiscriminate dilution as a satisfactory technique for the disposal of radioactive materials, particularly for long-lived radioisotopes, because the basic premise enunciated by the National Committee on Radiation Protection and others is that release of radioactive materials into the environment should be kept at a minimum. Certainly, dilution does not conform to this premise. All that has been accomplished is to reduce the concentration of activity but not the amount of radioactivity that is discharged. Besides, once released, control or recovery in case of an emergency, even if possible, may no longer be practical.

Nonradioactive Materials

The atomic energy industry uses materials with which the sanitary engineering profession has had very little experience. Some of these, such as zirconium, beryllium, mercury, and fluorides, as well as others, have been discharged. In addition, a variety of organic solvents, used during chemical processing, have been released and their effects on stream flora and fauna are not too well known.

EFFECTS OF STREAMS

Each element in the stream environment will have some effect on the radioisotopes discharged. In some cases, the effects may be minimal, in others very significant.

If the waste discharged and the stream are incompatible, precipitation may take place, and sludge banks containing adsorbed, occluded, exchanged, or assimilated radioactivity will be formed. During periods of flood or high velocity they may be transported to other areas, forming beds of even greater activity. In like manner, if the stream supports a plankton population capable of adsorbing large quantities of activity, the net effect, at least temporarily, will be to reduce liquid phase activity levels. Because of these and other factors including uptake by bottom muds,. by littoral vegetation, by fish, and by detention alone, the levels of activity in the water will be reduced. The permanency of removal is a point of great concern and interest and should be evaluated carefully. Such knowledge would be very beneficial since it would permit us to harness the capacity of the stream to reduce radioactivity much in the same way that we have utilized the self-purification capacity of the stream to assist in the breakdown of organic and other pollutants, providing such utilization does not interfere with other stream uses.

The stream, by dilution and dispersion, will dampen peak activities, and accordingly will reduce to some extent the actual uptake of activity by other agents.

EFFECT OF WATER TREATMENT PROCESSES

Considerable literature is available on the efficiency of conventional and modified water treatment processes for the removal of specific radioactive materials as well as mixtures of radioisotopes.[2,3,4] This information will not be repeated here in detailed form, but has been summarized and will be found in Tables 1, 2, and 3. Table 1 lists results obtained with conventional processes, Table 2 with modified processes, and Table 3 with mixtures of radioisotopes. In using these data one must recognize that differences are to be expected with other chemical forms of these radioisotopes, since commercially available solutions of isotopes were employed in these studies. It is best, therefore, to repeat these tests using local waters and radioisotopes in the form found in the waste stream. A second factor to remember when treating mixtures of radioactive materials is that removals may be low or high depending upon the composition of the mixture. For example, if a waste containing strontium and cesium is to be treated, little removal of the activity would be obtained with conventional chemical coagulation; whereas, higher removals would be expected if the waste contained polyvalent ions.

The levels of activity generally encountered at present have no effect upon the treatment process and will not interfere with it in any way.

EFFECT ON WATER TREATMENT PLANT PERSONNEL

In all probability the levels of radioactivity encountered in water treatment plants will be sufficiently low and no radiation hazard is anticipated. To ascertain this fact, however, measurements should be made from time to time, not only of the activity levels in the waters being treated, but of the levels in the material contained in the sedimentation tank and in the filter wash waters, and of the radiation levels from the walls of the various plant units, from pipes, or other appurtenances which are being handled, repaired, or replaced.

Metallic, concrete, wooden, and other surfaces may adsorb some radioactive materials. Biological growths in pipes, on walls of tanks, etc., will accumulate activity; these units should be checked for activity from time to time and the accumulated growths removed. Obviously, one method of reducing accumulation by biological materials attached to surfaces is to keep these surfaces free of such organisms.

TABLE I

REMOVAL OF RADIOACTIVE MATERIALS BY CONVENTIONAL WATER TREATMENT PROCESSES[1]

Isotope	Chemical Coagulation and Settling	Sand Filtration	Soda-Ash Softening	Ion Exchange Resins		
				Cation	Anion	Mixed Bed
	Ranges of Removal in Per Cent					
Cs-137 - Ba-137 (Cl)	0-37	10-70	<50	99+	9	99+
Sr-89 (Cl)	0-15	1-13	50-95	99+	5- 7	99+
Ba-140 - La-140 (Cl)	1-84	39-99	50-95	96-99	36-42	99+
Cd-115 (NO_3)		60-99	50-99	98	0	99+
Sc-46 (Cl)	62-99+	94-99	50-95	96-97	99	99
Y-91 (Cl)	1-99+	84-89	50-95	75-93	94-98	98-99
Zr-95 - Nb-95 (oxalate complex)	2-99	91-96	50-99+	58-75	96-99+	91-99+
P-32 (phosphate)	68-99+					99+
Cr-51 (Cl)	0-60					
Mo-90 (MoO_3)	0-60					
W-185 (tungstate)	1-96	3-18	<50	9-16	97-99+	99
Re-186 (metal)	0-29					
I-131 (iodide)	0-96				99+	99+
Ru-103 (Cl)	43-96					
Pr-142 (Pr_2O_3)	83-99+					
Ce-144 - Pr-144 (Cl)	28-99+					99+
Pm-147 (Cl)	4-99+					
Sm-153 (Sm_2O_3)	44-99+					

[1]Variable chemical dose, coagulants, pH conditions, activity concentrations and waters.

TABLE II

REMOVAL OF RADIOACTIVE MATERIALS BY MODIFIED PROCESSES[1]

Isotope	Phosphate-Coagulation	Metallic Dusts	Clay Additions[2]
	Ranges of Removal in Per Cent		
Cs-137 - Ba-137 (Cl)		9	98
Sr-89 (Cl)	81-98		49-52
Ba-140 - La-140 (Cl)		66-95	85-98
Zn-65 (Cl)	99+	98-99+	
Cd-115 (NO_3)			64
Sc-46 (Cl)			97
Y-91 (Cl)	99+	98	94
Zr-95 - Nb-95 (oxalate complex)	99+		96
P-32 (phosphate)		84-99+	78-82
Sb-124 (Cl)	66		
W-185 (tungstate)	11		49
I-131 (iodide)		23-46	9-20
Ru-106 - Rh-106		93-99+	
Co-60 (Cl)		30-92	85-99+
Ce-144 - Pr-144 (Cl)	99+	99+	99+

[1]Variable chemical quantities, levels of activity, and pH conditions.
[2]5,000 mg/l of clay added.

TABLE III

REMOVAL OF MIXED FISSION PRODUCTS ISOTOPES

Mixture*	Treatment Process	Per Cent Removal
FPM - 1	Coagulation and Settling Plus Clay	61 - 84
FPM - 2	Coagulation and Settling	9 - 71
	Coagulation and Settling Plus Clay	12 - 73
	Coagulation and Settling Plus Clay	46
	Coagulation and Settling Plus Filtration Plus Clay	70 - 73
FPM - 3	Coagulation and Settling	46
FPM - 4	Coagulation and Settling	89
	Mixed Cation-Anion Exchange Slurry	83 - 99
FPM - 5	Coagulation and Settling	51 - 59
	Mixed Cation - Anion Exchange Slurry	38
	Metallic Dust Slurry	8 - 56
FPM - 6	Metallic Dust Slurry	77 - 92

* FPM - 1 Iodine Dissolver Solution
FPM - 2 Synthetic Mixture
FPM - 3 Three-year Old Fission Products Mixture
FPM - 4 Iodine Dissolver Solution Aged 30 Days
FPM - 5 Mixed Fission Product Waste Containing Cs-137 - Ba-137 and Ru-106 - Rh-106
FPM - 6 Iodine Dissolver Solution Aged 20 Days.

REFERENCES

1. Straub, Conrad P. "Criteria for Waste Disposal," Proceedings, Ohio State University Health Physics Conference, June 13-15, 1955, Columbus, Ohio. pp. 4-15 (Released May, 1956).

2. Straub, Conrad P. "Limitations of Water Treatment Methods for Removing Radioactive Contaminants," Public Health Reports, 70: 9, 897-904, September, 1955.

3. Straub, Conrad P., Lacy, W. J., and Morton, R. J. "Methods for the Decontamination of Low Level Radioactive Wastes," Proceedings, International Conference on Peaceful Uses of Atomic Energy, August 1955, Geneva, Switzerland. Vol. 9, pp. 24-27, United Nations, New York, 1956.

4. Morton, Roy J. and Straub, Conrad P. "Removal of Radionuclides from Water by Water Treatment Processes," Journal, American Water Works Assoc., 48: 5, 545-558, May, 1956.

(See extensive reference listings in these papers for additional information.)